NOISE IN HOSPITALS: EFFECTS AND CURES

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2008 Gegenheimer Lecture Series in Innovation

- Motivation for current studies at JHH
- Why are hospitals noisy?
- What we found in the literature
- Noise measurements at JHH
- Some solutions

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Florence Nightingale (1859)

- "Unnecessary noise, then, is the most cruel absence of care which can be inflicted either on sick or well"

Open Literature on Hospital Noise

Intensive care units, Operating rooms, and Nurseries

Hospital tools (orthopedics)

Control of hospital noise limited to administrative control measures

Studies conducted mainly by physicians and nurses and reported in medical literature

Open Literature on Hospital Noise and its' effect on people

- Contribute to stress in hospital staff
- Noise negatively affects speed of wound healing
- Cataract surgery patients required longer stay during exposure to construction noise
- Additional medication required surgical patients when SPL >60dB
- Noise effects on performance ?????

Table of sound levels L and corresponding sound pressure and sound intensity

Examples	Sound Pressure Level L_p dBSPL	Sound Pressure p $N/m^2 = Pa$
Jet aircraft, 50 m away	140	200
Threshold of pain	130	63.2
Threshold of discomfort	120	20
Chainsaw, 1m distance	110	6.3
Disco, 1 m from speaker	100	2
Diesel truck, 10 m away	90	0.63
Kerbside of busy road, 5 m	80	0.2
Vacuum cleaner, distance 1 m	70	0.063
Conversational speech, 1m	60	0.02
Average home	50	0.0063
Quiet library	40	0.002
Quiet bedroom at night	30	0.00063
Background in TV studio	20	0.0002
Rustling leaf	10	0.000063
Threshold of hearing	0	0.00002

Existing Hospital Noise Guidelines

- **World Health Organization**
  - Lmax(A) no more than **40** dB(A)
  - Leq of **30** dB(A) in rooms
- **ANSI Standard S12.2-1995**
  - RC(N) values of **25-40** depending on type of room
  - NCB values of **25-43**
- **US EPA "Levels" Document**
  - Ldn of no more than **45** dB(A)

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Our Project on Hospital Noise

- Fully characterize noise in JHH.
  - As a function of time of day
  - Different locations
  - Octave bands
  - Source identification
- Work on noise control issues.
  - Architectural design
  - New materials
  - Active and passive noise control
- Special Issues
  - Privacy
  - Speech communication errors

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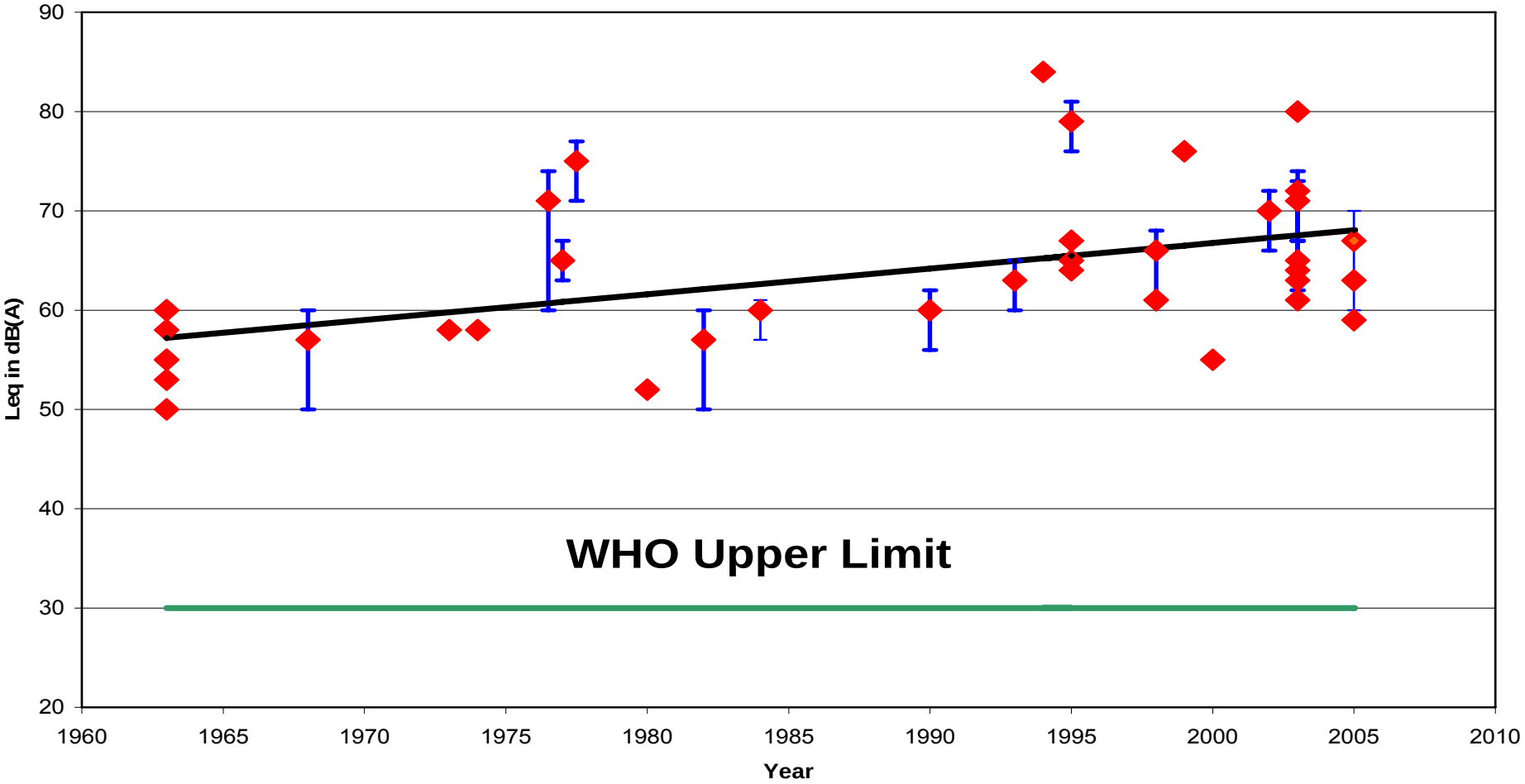
Sound pressure levels measured in hospitals as a function of the year of publication



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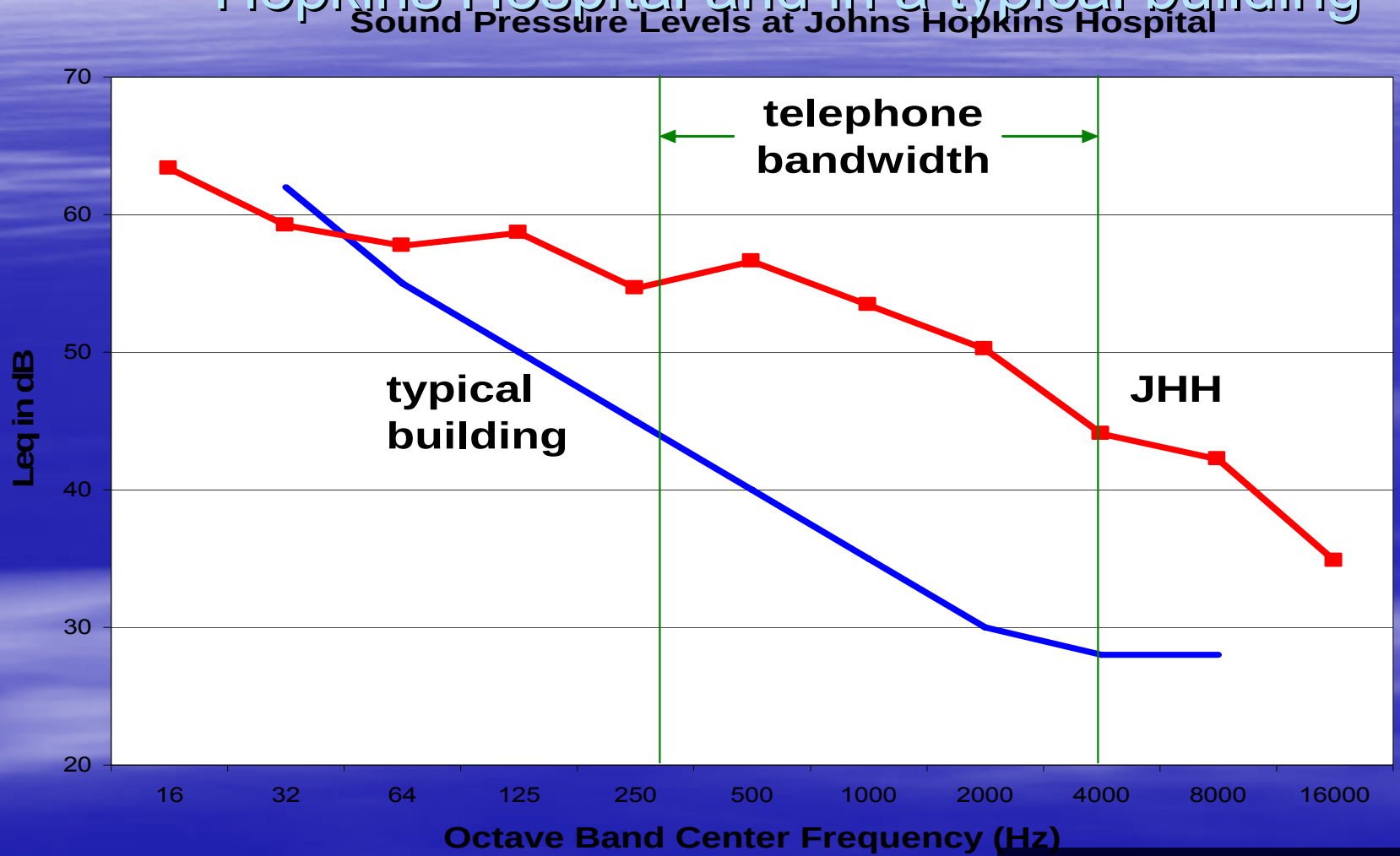
Sound pressure levels in octave bands at Johns Hopkins Hospital and in a typical building



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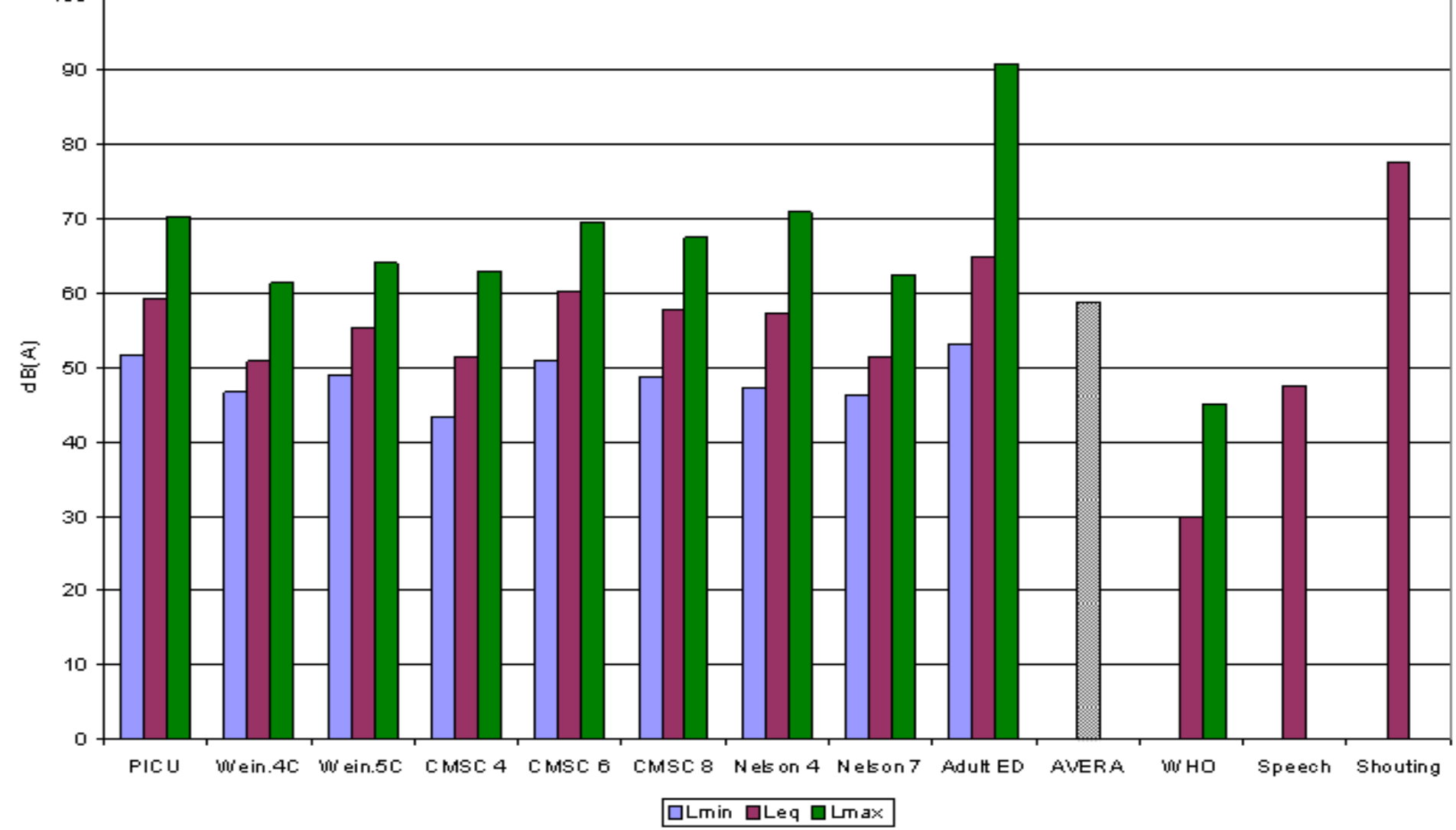
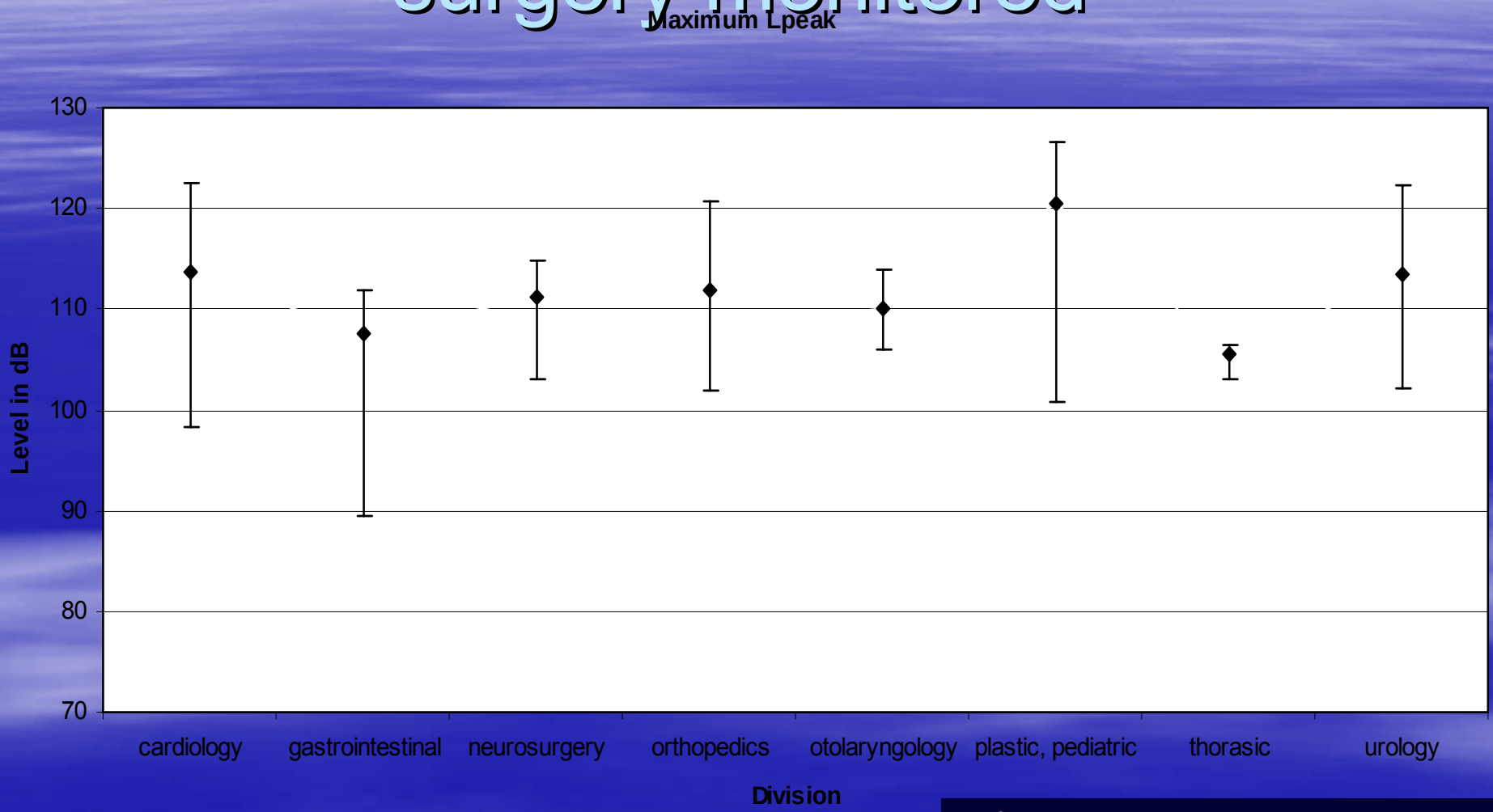


Figure 2: Sound pressure levels in various units of JHH, including old buildings and new. Also shown is the hospital average Leq, the WHO recommended maximum levels, and typical levels for speech and shouting.

Average sound levels for surgeries by category

Division	No. of Surgeries	Ave. Level dB(A)	Range dB(A)
Pediatric Orthopedic	2	57.9	56.8 – 58.7
Gynecological	2	60.2	54.4 – 63.4
Thoracic	4	62.9	61.6 – 63.6
Gastrointestinal	9	62.9	54.9 - 68.8
Cardiology	10	63.4	57.1 – 67.8
Urology	11	63.6	55.6 – 67.0
Pediatric Urology	2	64.1	64.0 – 64.1
Neurosurgery	8	64.5	60.2 – 67.3
Otoloaryngology	4	64.8	53.0 – 66.4
Pediatric Plastic	4	65.2	62.2 – 68.4
Orthopedic	19	66.3	56.7 – 70.3
Plastic	3	66.9	58.8 – 68.9

Maximum L(peak) for each surgery monitored



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QUIETING WEINBERG 5C

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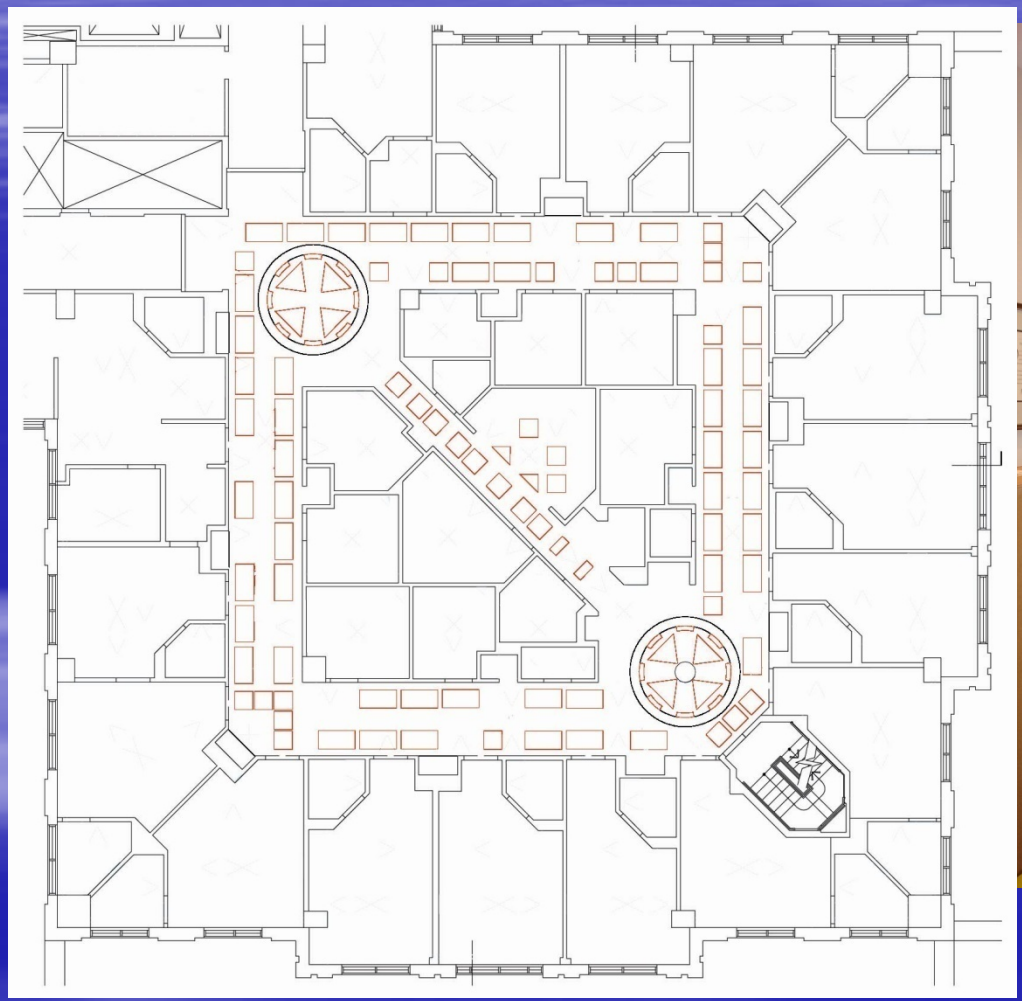
Weinberg 5C



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Installation

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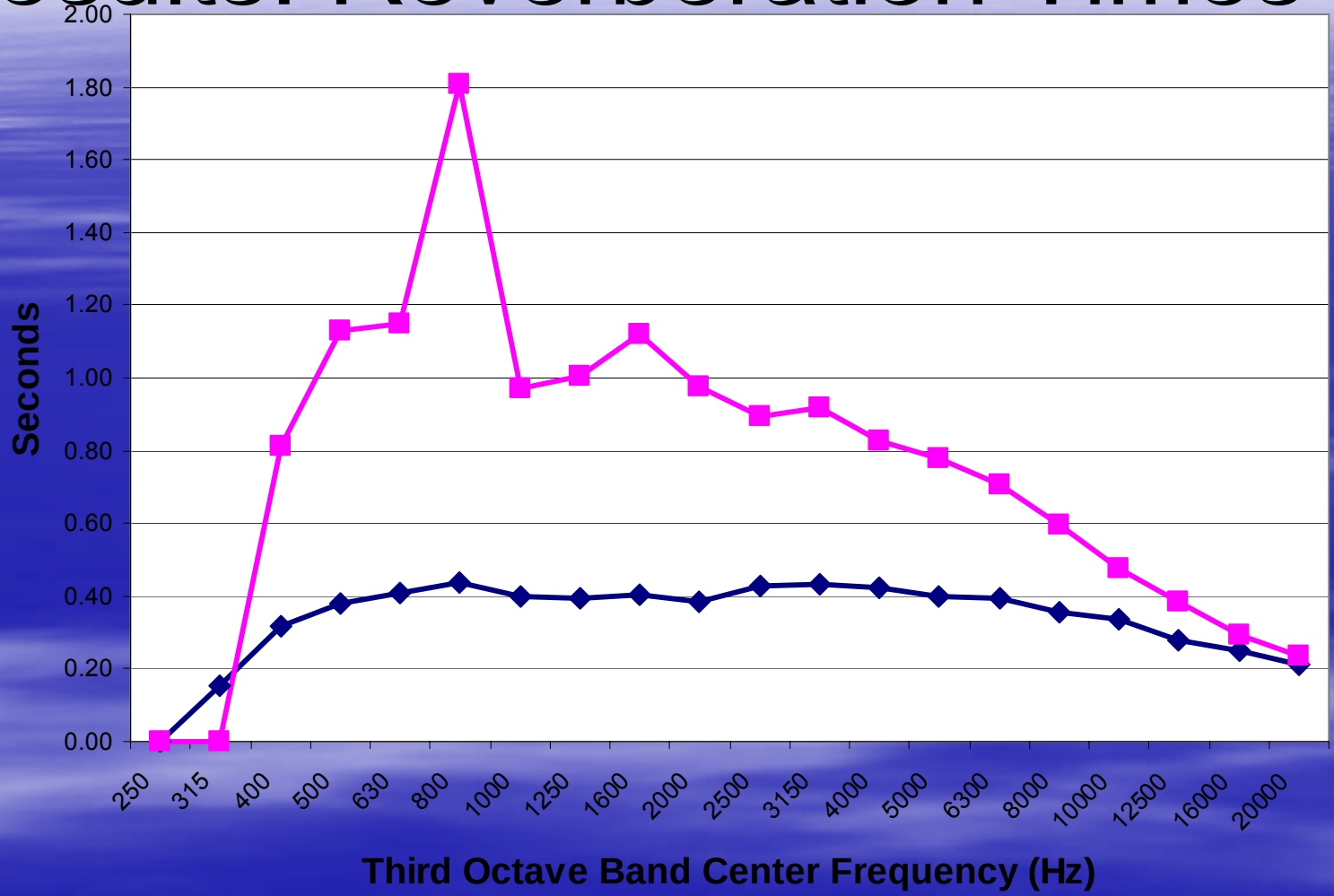
Results: Reverberation Times



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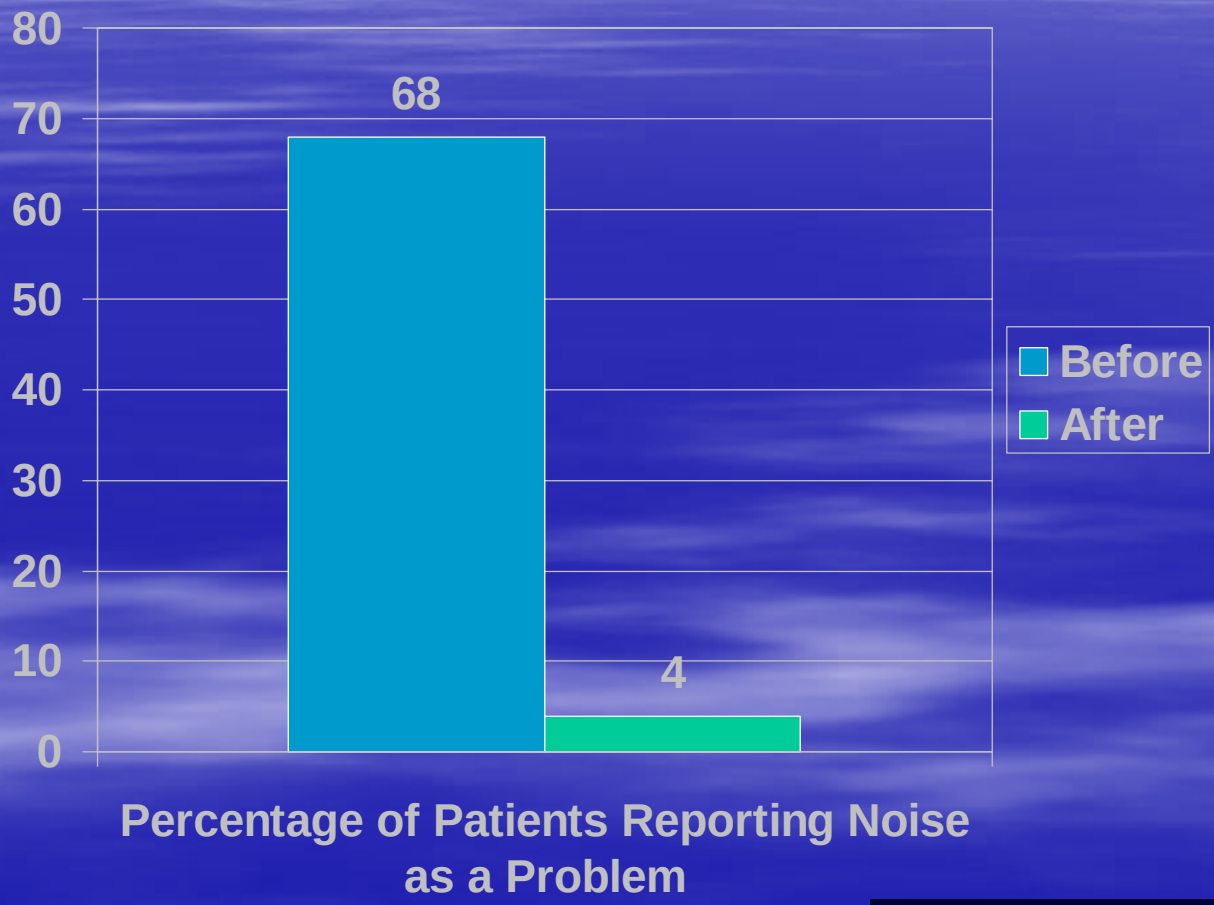
Subjective Results - Patients



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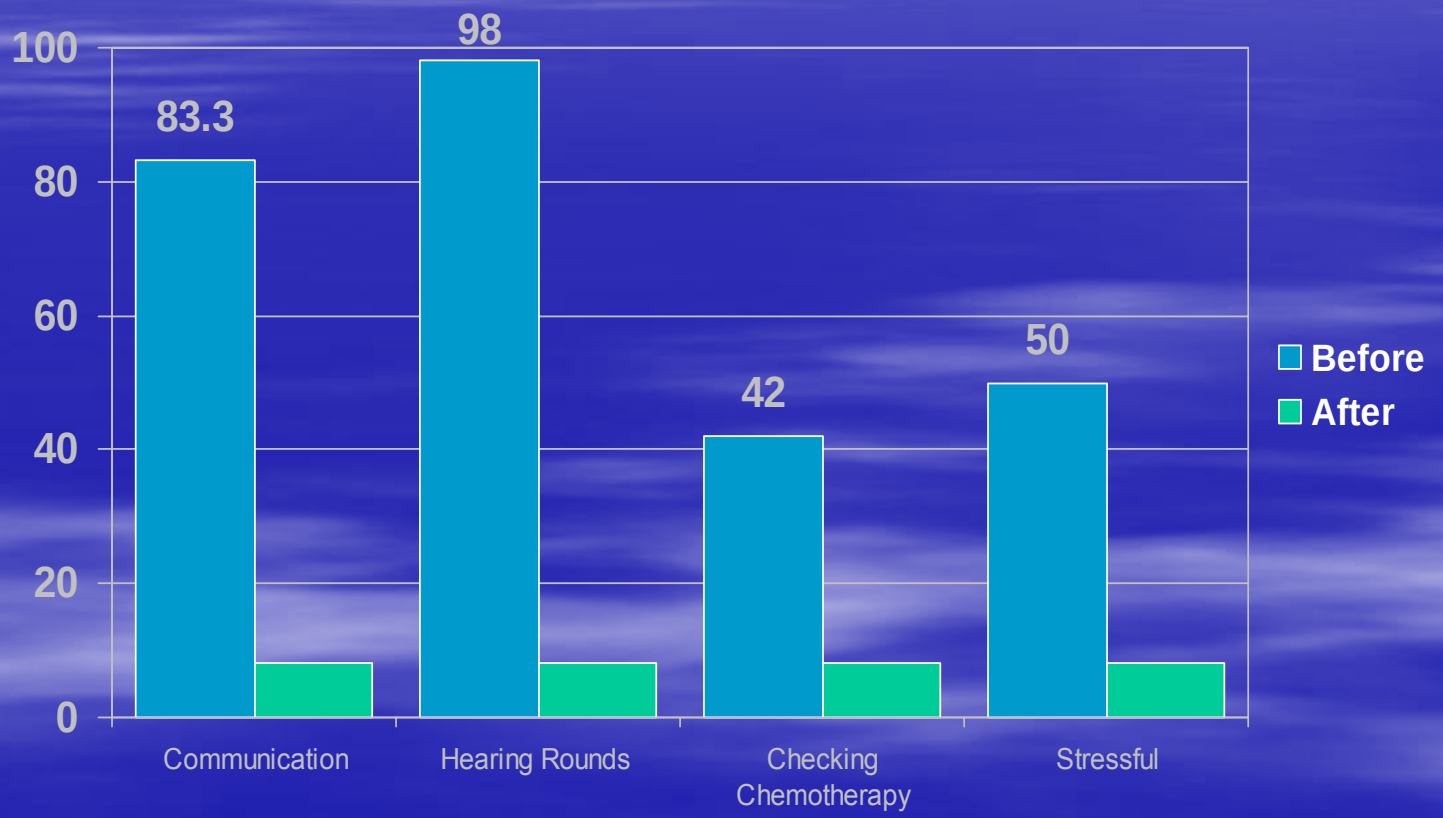
Subjective Results - Nurses



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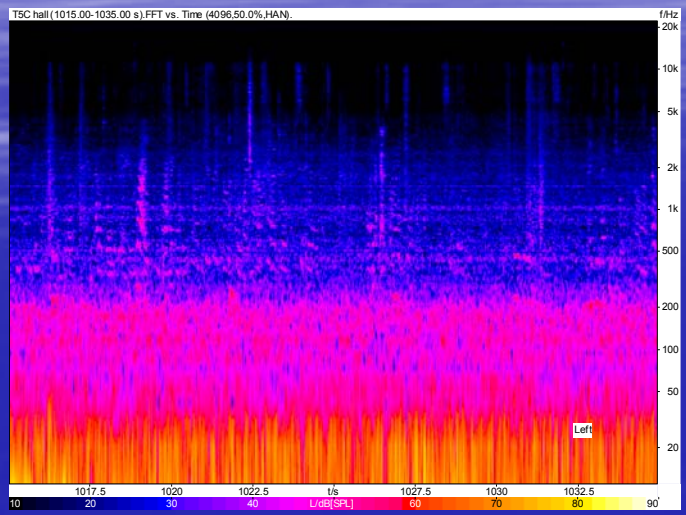
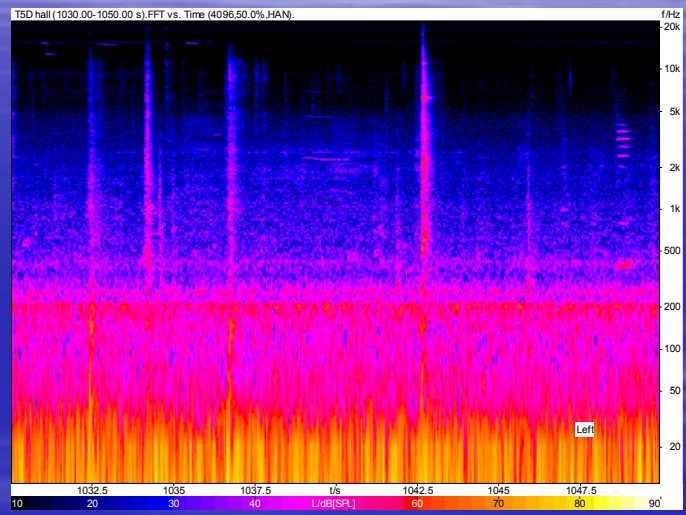
Comparison of FFTs

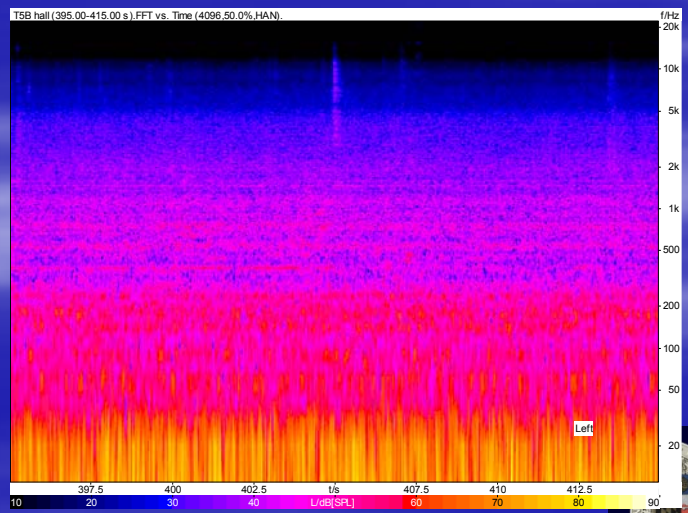
W5C



W5D



W5B



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SII

Described in ANSI S3.5 – 1997

We used the octave band approach.

Results in a number between 0 and 1 .

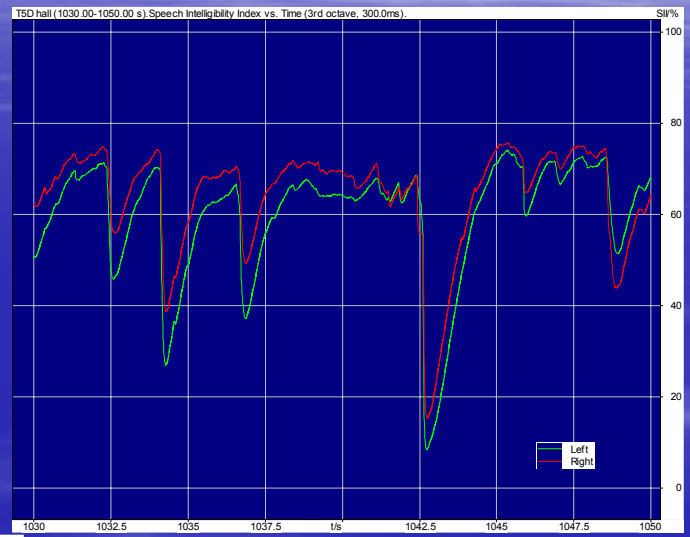
0 is clearly awful, and 1 is clearly great.

The quality between 0 and 1 is NOT well defined!

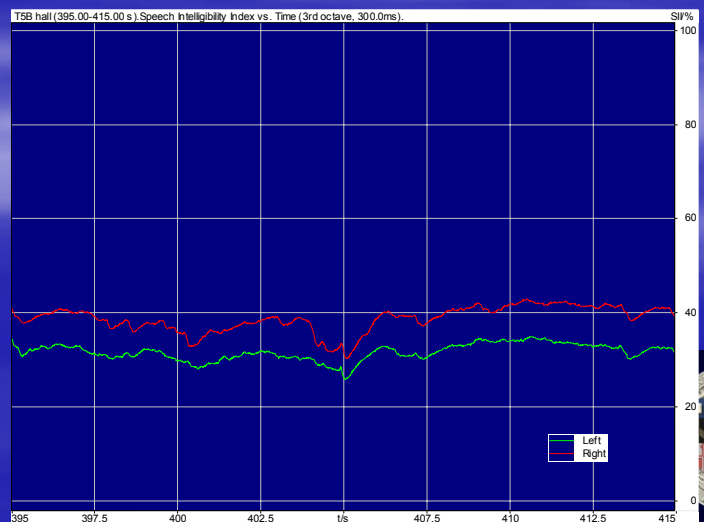
Speech Intelligibility Index vs. Time

W5C: SII= 0.8

W5D: SII=0.5



W5B: SII=0.35



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Research Needed

1. What acoustical measures best correlate with patient and staff outcomes?
   - Is it level alone that predicts outcomes or spectral content or variations in these?
   - Which medical outcomes should we monitor – hospital stay length, need for pain medication, need for sleep meds?

   - *Ideally, we would like to determine a causal relationship.*

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More Research

2. What changes in acoustical measures are produced from a variety of noise interventions?
   - Interventions could include better doors for patient rooms, earplugs for patients, masking noise, absorption on walls, …

Results from 1 and 2 could let us determine which noise interventions are most likely to produce positive medical outcomes.

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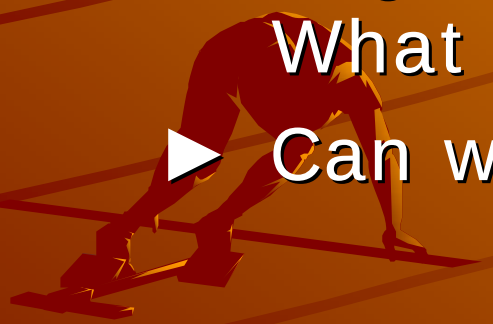
More Research

3. To what extent do medical errors in hospitals correlate with noise?
   - There is significant work in this area ongoing for pharmaceutical confusion. What about other kinds of errors?
   - Can we establish a causal effect?



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Frequency and Neighborhood Effects on Auditory Perception of Drug Names in Noise (Lambert)

- 3.9 million “wrong drug” errors in US retail pharmacies each year (e.g., Zyrtec/Zyprexa, Celebrex/Celexa, Toradol/Tapazole), many due to confusion between similar names
- Auditory perceptual identification task (noise)
- Data collection ongoing, preliminary results

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More Research

4. What is the best way to design hospital units to reduce noise while preserving efficiency and effectiveness of operation?
   - A report by Ulrich, et al. showed that the single most important factor in reducing hospital noise is single patient rooms.
   - How do we balance staff convenience with designs that reduce noise?

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5. How might hospitals cope with requirements for speech privacy?
   - Masking is NOT a possibility in most cases.
6. Given the desire to move to a more digital hospital, what level of noise mitigation is needed for accurate speech recognition?
   - How do we achieve BOTH privacy and accurate speech recognition?
   - Can we improve speech recognition in noise?

Research Continued

7. As operating rooms shrink in size and theaters disappear, how do we create a means for students to experience surgery from a distance?
   - Simulations to date don't include realistic operating room audio
   - Remote viewing rooms don't take advantage of multi-channel audio to produce realistic sounds.

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Research Continued

8. What is the relationship between noise and performance for a variety of important tasks in hospitals?
   - The literature on the influence of noise on surgical tasks is not conclusive.
   - What noise measures correlate with degradation of task performance quality?
   - Which tasks are most susceptible to noise influence?

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Still More Research

10. Can we manufacture quiet medical equipment?
    - Which equipment contributes the most to annoyance or negative outcomes?
    - Why are those darn carts so noisy?!?!

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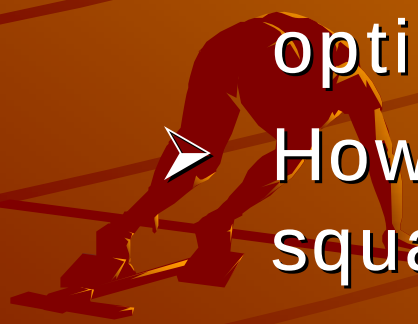
Finally

11. How can we communicate in hospitals without overhead paging?
    - There is one system available for hands-free communication. Is it optimal?
    - How can a hands-free system be squared with privacy?



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What will it include at Johns Hopkins Digital Hospital

- Digital imaging and data integration
- Multi-modal interactive devices (televisions, monitors, video phones)
- Wireless communications; pervasive and ubiquitous
- Voice Recognition and Speech recognition
- Wearable communication devices

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